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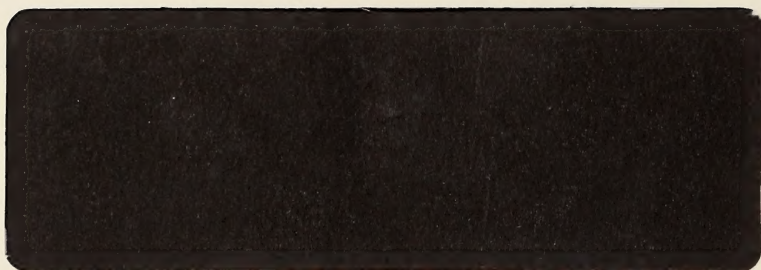
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development which will reduce housing costs,
performance of dwelling units and subdivisions,
in visibility and accessibility of Alberta's

**EXTERIOR WALL OPENING COVER
FITTING FOR RESIDENTIAL
CONSTRUCTION**

Alberta
MUNICIPAL AFFAIRS
Innovative Housing Grants Program



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FOREWORD

EXTERIOR WALL OPENING COVER FITTING FOR RESIDENTIAL CONSTRUCTION

May, 1988

Based on material prepared by:

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and

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University of Alberta

For

Enduro Siding Ltd.

The views and conclusions expressed
and the recommendations made in this
report are entirely those of the
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FOREWORD

The project documented in this report received funding under the Innovative Housing Grants Program of Alberta Municipal Affairs. The Innovative Housing Grants Program is intended to encourage and assist housing research and development which will reduce housing costs, improve the quality and performance of dwelling units and subdivisions, or increase the long term viability and competitiveness of Alberta's housing industry.

The Program offers assistance to builders, developers, consulting firms, professionals, industry groups, building products manufacturers, municipal governments, educational institutions, non-profit groups and individuals. At this time, priority areas for investigation include building design, construction technology, energy conservation, site and subdivision design, site servicing technology, residential building product development or improvement and information technology.

As the type of project and level of resources vary from applicant to applicant, the resulting documents are also varied. Comments and suggestions on this report are welcome. Please send comments or requests for further information to:

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EXECUTIVE SUMMARY

THE PROBLEM

Modern wood frame residential housing requires numerous penetrations of the exterior weather membrane for electrical outlets, light fixtures and service connections which create potential air, water, dirt and insect infiltration sites. These penetrations also cause problems fitting the exterior cladding in an attractive manner. Despite the extra installation effort required by the trades persons and extra coordination required by the contractor, many exterior wall penetrations fail to provide effective barriers to air, dirt, water or insects and are all too frequently unattractive in appearance.

THE SOLUTION

The Enduro external wall opening cover (EWOC) was proposed as a solution and is the subject of this investigation. An EWOC consists of an injection molded plastic baseplate attached to the exterior sheathing, at once providing a smooth, rigid, and weather-resistant surface for the exterior fixture and a frame for fitting the exterior siding against. The baseplate will cover and seal oversize or irregularly shaped sheathing openings caused by poor workmanship or error. A slide-in trim piece or "top hat" covers the siding edges giving an attractive, professionally finished appearance.

MARKET RESEARCH

This market research, completed in September 1987, was undertaken as a result of the feasibility study conducted in June 1987 which indicated a positive market response to the product, but failed to provide specific

information on the potential market and acceptable pricing levels. At that time, a prototype was unavailable for demonstration purposes and the product concept was not clearly defined.

The research consisted of three sections. The first two sections were personally administered to builders and siders in the Edmonton area. The focus of the first section was to examine the relative importance of various attributes in the decision making process. Price, color of the J trim insert, brand name and color of the base piece were the four attributes considered. Three levels of each attribute were presented to the research participants using conjoint analysis.

The second section dealt with the identification of the market participants and their satisfaction with current finishing methods for these openings.

The third section had the same focus as Section Two, however, the respondents were members of the Canadian Home Builders' Association. This provided for a measure of market response from across Canada.

The results of the research indicated a positive response to the product, although this varied between provinces. Nationally, there was at least moderate concern expressed about the appearance of these openings, the labour involved, and the effects that the openings had on the energy efficiency of the homes.

The most significant factors in the decision making process for the majority of the respondents were price and color of the J trim insert followed by the brand name and color of the EWOC base.

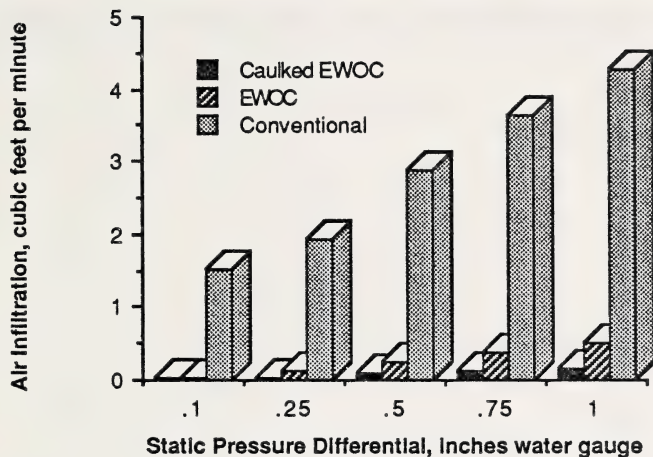
Based on the research findings, it is recommended that the product be priced at \$2.99 per unit, consist of a J trim color offering of white, beige and brown, and be complemented by a matching or a white EWOC base.

THE INVESTIGATION

A review of current practices indicated that penetrations of the exterior membrane by services was an area of building technology that had not kept pace with the generally improving technical construction procedures. In part, this was attributable to the lack of fittings to facilitate the development and acceptance of a standardized technique. Widespread use of EWOC fittings is anticipated due to the apparent need and may, in fact, lead to the development of a standardized method of preparing and finishing such openings.

During this investigation, the EWOC evolved into the present two piece design. The baseplate, structurally stiff and rugged, is injection molded of impact resistant material. Modular design accommodates electrical duplex receptacles, saucer and octagon electrical boxes, dryer vents and water bibs or gas line with the same parent casting. Simple economical mold inserts allow all variations to be injected from one mold. The "top hat" trim piece, vacuum formed from ultraviolet (UV) radiation resistant material, protects the baseplate from UV exposure while allowing variety of trim colours. Damaged top hats are readily replaceable by the homeowner.

A field survey indicated that considerable air infiltration could be expected through conventionally installed exterior electrical outlets. Hence air infiltration testing was conducted on a simulated exterior wall section using various conventional and EWOC duplex electrical outlet configurations. As illustrated graphically in the accompanying figure, the EWOC provides very substantial air infiltration reductions over conventional installations. Similar improvements in water, dirt and insect resistance would apply.



Note: Data below 0.7 inches water gauge for the EWOC and 0.25 inches for the conventional installation have been extrapolated from test results.

CONCLUSIONS

The EWOC is a cost effective solution to the problem of finishing exterior cladding penetrations in residential construction in an attractive, professional manner for all common exterior finishes. In addition, it is a technically superior construction technique that greatly reduces the infiltration of air, water, dirt and insects compared to present practices. This will contribute to reducing structural and cladding damage due to weather exposure.

At the time of writing, EWOC's are produced in two models — duplex electrical outlets and exterior lighting fixtures. Baseplates are injection molded ABS and the top hat is vacuum formed from ultraviolet and

impact resistant PET (polyethylene terephthalate). Modular mold inserts will allow an expanded product line as market demand develops.

1.0 INTRODUCTION

1.1 General

In recent years, significant advances in residential housing construction techniques have occurred, often under the impetus provided by the need for energy conservation. This has led to the development of superior vapor and air infiltration barriers and generally improved outer building envelopes to resist weather. Much of the latter is due to the development of factory fabricated fittings, flashings, soffits and the like. These not only improve the quality of construction but frequently increase labor efficiency. One area where improvements are sadly lacking is protection of exterior envelope penetrations by utilities.

Many penetrations are necessary in the exterior weather envelope for fixtures and services. Generally increasing living standards have greatly increased the number of penetrations in the average residence in recent years. Penetrations include electrical outlets and light fixtures, dryer and cooking vents, fresh air intakes for furnaces and fireplaces, electricity service entrances and water and gas outlets. Exterior finishes, such as siding or stucco, must fit neatly to these openings not only for appearance but also to minimize infiltration of air, dirt or water into the wall cavity. Currently the lack of suitable fittings or covers makes this difficult to accomplish.

Enduro Siding Ltd. proposed a solution involving a plastic fitting that is attached to the sheathing prior to the finish siding application. The fitting would provide a leak-proof seal against air, water and dirt and provide regular surfaces to finish the exterior cladding against.

In order to develop this simple but elegant solution, Enduro Siding Ltd. applied for assistance under the Innovative Housing Grants Program. Assistance was required in market assessment, engineering design and testing and materials selection.

1.2 Objectives of the Project.

The stated objective *“is to develop, test and certify a new plastic exterior wall opening cover to improve the utility and performance of current exterior finishing and sealing techniques around exterior openings”*. Generally stated, the detailed objectives were to:

- perform a feasibility study to estimate future markets, assess competitive methods and determine acceptable product costs for a full range of cover types;
- design a product and produce a prototype suitable for use with duplex electrical receptacles;
- perform appropriate prototype testing to refine the concept and to satisfy certification requirements;
- establish production procedures including quality assurance procedures;
- apply for product certification with appropriate regulatory authorities; and,
- document the above process in a comprehensive report.

The above objectives were addressed by several parties. This report relates to the design, materials selection, testing and market assessment of the product. The detailed engineering objectives were to include:

- engineering design of the product including detailed dimensional requirements;
- selection of appropriate plastic material and production methods;
- locating a manufacturer who could produce the product at competitive costs;
- build a number of prototypes for in-house, laboratory and field trials;
- test the prototypes for water leakage, air infiltration, impact resistance, environmental life tests and installation trials;
- redesign the product, as necessary, from the results of the testing program; and,
- select the optimum molding method and mold type to produce the product.

During the course of the project, the design evolved quite differently from the original concept requiring changes in the engineering objectives. Further, as the product was originally envisaged, vacuum forming would have been the manufacturing method. This method was abandoned in favour of the injection molding process as a result of the design review which indicated the necessity of greater dimensional accuracy and structural

stiffness for the base flange component. Injection molding produces a product with established methods of predicting the product's physical, weathering and ageing properties, which are discussed under Section 3.0, Materials Selection. Hence much of the original anticipated testing was considered unnecessary.

2.0 ENGINEERING DESIGN

2.1 Current Practice

The present discussion is limited to exterior duplex electrical receptacles. However, the EWOC, as designed and presented in this report, will also accommodate exterior light fixtures, dryer vents, water bibs and natural gas (barbecue) outlets.

The conventional method of installing exterior electrical outlets in frame construction involves cutting a hole in the exterior sheathing next to a stud to accommodate the electrical box. The box is attached to the stud so that it extends beyond the sheathing to the thickness of the siding to be applied later. This requires fore-knowledge of the siding type by the electrician. Installation of the duplex receptacle and the standard weather-proof cover can occur at this time or after the siding is applied. Next, the siding applicator applies building paper and siding which must be cut to fit around the outlet. Depending on the exterior finish, caulking may be applied in an attempt to seal around the box.

The above method is subject to many problems since the fit-up and appearance depends on the quality of the workmanship which is hampered by the involvement of two trades. It is not uncommon for electrical boxes to protrude to the extent that the box is exposed to the elements after siding installation, causing corrosion to the duplex receptacle and greatly increased air and dirt infiltration. The builder must co-ordinate between trades to achieve the correct protrusion of the box and hence fit with the siding trim. Such co-ordination is often difficult to achieve under field conditions.

In many installations the building paper is exposed allowing moisture penetration into the box behind the building paper and perhaps into the wall cavity, depending on rain direction, wind speed and a host of workmanship variables such as care in trimming the building paper, the size of the hole in the sheathing, or crooked box installation.

Over sized and poorly cut openings in the sheathing are commonplace. Less frequently but all too commonly, the sheathing opening, especially in wafer boards, will be created or enlarged by hammer blows. Usually this does not affect the finished appearance. However, undesirable infiltration of air, water and dirt is increased due to difficulties in making a proper or complete seal with standard weather-proof coverplates.

In recent years, building technology has improved significantly. Greater theoretical understanding has led to practical advances in controlling thermal and air infiltration losses, establishing ventilation systems to prevent condensation, heat losses and building material damages, ensuring proper pressure differentials for operation of appliances such as furnaces and fireplaces, increasing the integrity of the external weather-proof membrane and use of engineered products to achieve greater material efficiencies such as trusses and stressed-skin panels or membranes. However, improvements to exterior sheathing penetrations for electrical outlet boxes has been restricted to the application of better caulking compounds developed for other purposes. Unfortunately, the caulking must be applied in locations involving different construction materials including building paper and often having geometries which are difficult to caulk leading to shorter caulking service life. The application of caulking is extremely dependent on workmanship and requires considerable

inspection by the contractor to ensure an adequate job. Furthermore, the use of caulking tends to excuse poorer quality fitting since a "caulking will take care of it" attitude develops.

The Enduro exterior wall cover outlet addresses this problem of exterior wall penetration for electrical fittings by providing a simple, cost-effective, more technically sophisticated hardware approach creating a standard method of exterior electrical outlet installation. The prime advantages are provision of a smooth, weather-resistant surface for the installation of the weather-proof cover plate and a border to allow neat and workmanlike finishing of the siding or stucco that does not require co-ordination between trades on behalf of the builder. A slide-in trim top hat quickly finishes the installation giving a professional appearance. A side benefit is greater integrity of the exterior membrane opening resulting in lower air infiltration rates.

2.2 Field Observations

In order to assess the general quality of workmanship, an informal field survey of exterior wall penetrations was conducted in a residential area under construction in Edmonton. The writer was surprised at the generally poor quality of the average installation observed in a random sampling. No attempts were made to statistically quantify the installation quality but the survey represented only eight houses at three different sites. Mr. Arbter, Enduro Siding Ltd., assured the writer that these samples were not unusual and represented common practice.

A common practice is to cut the sheathing by drilling a series of holes with a spade bit and then to knock out the center with

hammer blows. This results in oversize and irregularly shaped holes which are larger than the weather-proof outlet cover's gasket precluding any possible air seal even if the cover plate fitted against the sheathing.

Oversize holes cut with sabre saws were common. While these openings have smooth edges, the areas are excessive for no apparent reason other than haste which has the effect of making an air seal impossible using conventional practices.

Generally the location of the opening relative to the siding pattern cannot be predetermined. Hence siding fit-up is often difficult and neither the saucer box nor the electrical outlet can be effectively air sealed due to the siding pattern. Water infiltration is likely in the case of outlets (saucer boxes are usually protected by the eaves' overhang). Poor fit-up provides ready access for insects (flies, wasps or bees).

Application of weatherproof coverplates will protect the electrical receptacle against air or water infiltration from the front. However, the sides, top, and bottom of the outlet box are frequently exposed to the weather. Also the coverplate gasket often cannot seal against the siding pattern geometry. Another sealing problem is that siding flexibility prevents any pressure being applied by the gasket without causing siding deflection. Attempts to prevent infiltration by caulking around openings often lead to unattractive results.

Light fixtures are normally not exposed to a high water infiltration risk due to their installation higher up the wall and usually under protective eaves. Nevertheless, the saucer box usually ends up exposed, allowing air, dust and insect infiltration. Attempts at sealing using caulking are usually unattractive.

In summary, current practices frequently result in aesthetically poor finishing of openings which are subject to air, water, dirt and insect infiltration. Even in attractive installations, attempts to seal weatherproof coverplates against the siding will permit excessive infiltration. The causes appear to be three-fold: workmanship (primarily in cutting sheathing and siding openings), lack of a solid base for mounting of the weatherproof coverplate or exterior fitting and absence of a simple trim installation procedure for finishing the opening. One might note that the EWOC fitting presented in this report would satisfactorily seal all of the previously described wall openings.

2.3 Exterior Wall Opening Cover Design Criteria

Three basic goals are behind the EWOC concept. These are as follows:

- improved aesthetics by providing a professionally finished appearance for exterior wall openings and siding fit-up;
- enhanced resistance of the exterior housing membrane to air, water and dirt infiltration by provision of regular surfaces for sealing thereby increasing energy efficiency and structure life; and
- increased labour and contractor efficiency.

A review of these goals and current practices lead to the establishment of the following design criteria:

- the EWOC must accommodate oversize and poorly formed sheathing openings while permitting adequate sealing between the EWOC and the sheathing;
- the EWOC must provide sufficient structural rigidity to allow proper sealing of the weather-proof coverplate and to resist deflection due to pressure differentials;
- the EWOC must be weather and impact tolerant because it is applied beneath the finish siding making replacement difficult;
- the visible EWOC components should be able to be simply replaced if damaged;
- the EWOC must be compatible with all common residential exterior finishes; and
- the EWOC must suit the dimensions of commonly used electrical outlet boxes.

2.4 Mechanical Design of the Exterior Wall Opening Cover

The general EWOC concept in this project is illustrated in Figure 1.

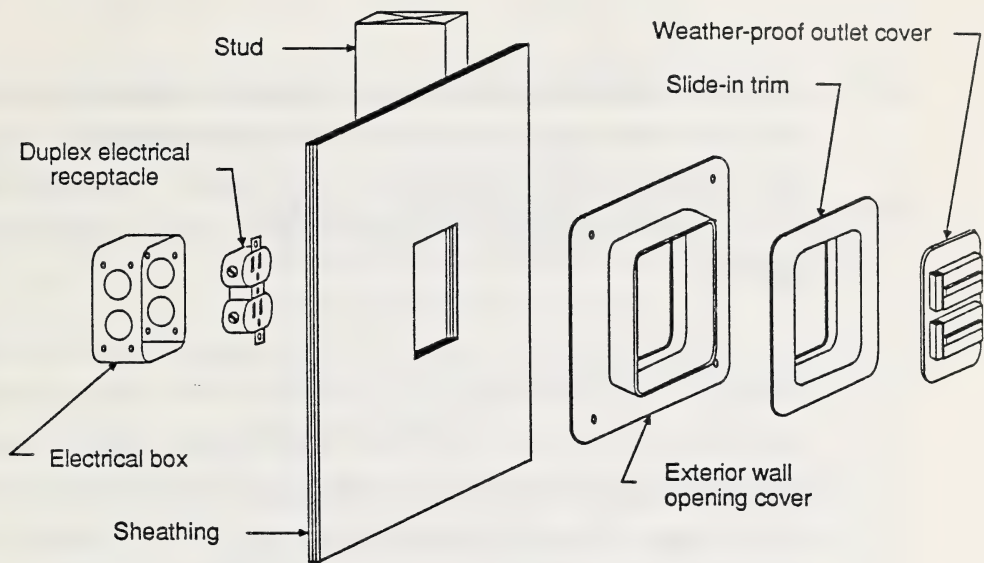


Figure 1: Exterior Wall Opening Cover Concept

An injection molded fitting is attached to the sheathing simultaneously providing a consistent mounting for the weatherproof cover and a frame for finishing the siding. A separate, ultraviolet resistant trim piece covers the fitting and finishes the opening. Various trim colours can be provided.

Considering the injection molded EWOC base section first, it consists of a 188 mm (7 3/8 inch) square plate that is fastened to the sheathing by screws or large headed nails. Foam gaskets of weatherproof duplex receptacle coverplates can seal efficiently against its smooth surface. A 16 mm (5/8 inch) high web forms a 136 mm (5 3/8 inch) square box which acts as an efficient stiffener to resist bending stresses caused by installation or differential air pressures. A cut-out at the centre of the plate accommodates a standard duplex receptacle box. The square enclosed by the raised web is large enough to allow easy operation of the weather-proof coverplate closures even if brick siding is applied. In fact, the square was dimensioned to allow one EWOC body

casting to accommodate saucer or octagonal boxes, water bibs and dryer vents merely by changing the central opening. This is economically achieved by different mold inserts. The raised web acts as a stop to butt the cut edges of vinyl, metal or wood siding against.

The cover trim has been designed as a vacuum or as an injection molding. Again, one exterior size and shape with different central openings can be used for different applications. The trim piece slides into the raised web cavity of the EWOC and is held in place by the coverplate, light fixture or the like. At the current depth it will suffice for vinyl, metal and some wood sidings as well as for stucco. Deeper sidings can be accommodated by increasing its height. If damaged, the trim can be changed in minutes by the homeowner.

Injection molding was chosen for the base section for its close dimensional tolerances and its ability to produce a more complex geometric configuration. Vacuum forming was selected to economically produce the geometrically simple trim pieces. The process combination endeavors to produce a high quality, durable product at a reasonable price. This will prevent competitors from offering a better quality product and should extend the competition-free marketing time.

2.5 Installation of the Enduro Wall Opening Cover

EWOC installation is extremely simple as is shown in the installation instructions reproduced in Appendix 1 and in Figure 1.

Several advantages which accrue as a result of EWOC installation are listed below:

- protrusion of the electrical outlet box beyond the stud is greatly reduced making for a more secure and square attachment to the stud;
- over-sized or irregular openings in the sheathing are accommodated;
- direct fitting of the EWOC against the sheathing allows effective sealing by a gasket or caulking;
- a smooth, easy to seal surface exists for the weather-proof cover plate gasket;
- a convenient butt stop and cutting guide for siding installation is provided by the raised web;
- minor (or even relatively major) siding cutting errors are covered by the slide-in-place trim;
- protection of the receptacle or fixture from water flow down the exterior cladding is provided; and
- a professional appearing finish is accomplished with less effort than by current techniques.

Widespread use of the EWOC could lead to a standardized method of finishing exterior wall openings where none now exists. Under such circumstances, labour efficiency and the technical sophistication of construction techniques will improve without constant vigilance by builders or inspectors.

Installation of EWOCs for fixtures other than electrical outlets is accomplished in a similar manner to that shown in Figure 1. The trade responsible for the opening merely finishes his work flush with the sheathing and the EWOC fixture allows straightforward application of the siding. Installation of the EWOC can be by the first trade or by the sider. In some cases, for example, water bibs, the EWOC is better installed by the original trade.

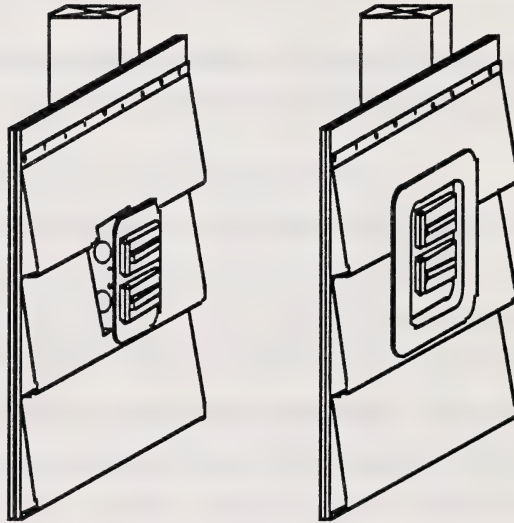


Figure 2: Comparison of Conventional and EWOC Exterior Duplex Receptacle Cladding Installations With An Exterior of Siding.

As shown in the above comparison with a conventionally installed outlet, the EWOC provides a more aesthetic, professional appearance while providing weather resistant sealing to the entry of air, water or dirt into the electrical box or the building structure.

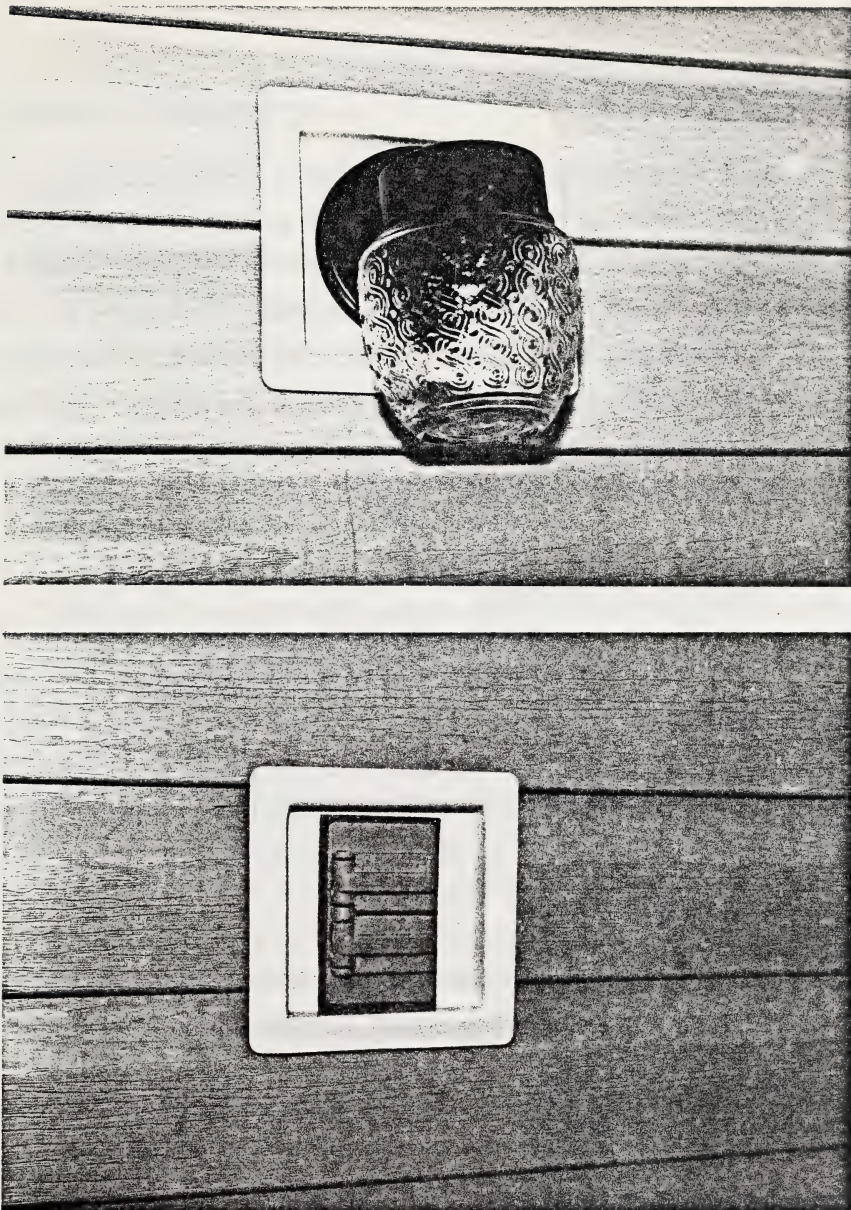


Figure 3: Photographs of Installed Production EWOC's

Vacuum formed PET "top hat" trim pieces quickly and economically finish exterior lights and electrical outlets with a professional aesthetic appearance. The protected ABS base plate effectively seals the exterior membrane opening, reducing infiltration of air, water, dirt and insects.

2.6 Patents

At the investigation's onset, Enduro Siding Ltd. arranged for a computerized information retrieval search to be conducted on a world-wide patent data base by the Industrial Technologies Department, Alberta Research Council. This search did not reveal any patents issued to similar devices. While it is recognized that the above search does not carry any legal weight, nonetheless the possibility of infringing on existing patents is considered remote.

2.7 Applicable Standards

Inquiries were made to various standards writing and regulatory authorities by Enduro Siding Ltd. to determine if the EWOC must conform to any existing standard. At the time of writing no such applicable standards or specifications exist. The EWOC was not considered to be an electrical device by any of the authorities canvassed.

CMHC currently do not have any specifications for such devices but expressed interest. A formal application for a CMHC acceptance number has been initiated (see Appendix).

3.0 MATERIALS SELECTION

3.1 General

Plastic materials have been gaining favour as materials for residential construction in recent years. These range from waste drain and vent piping, hot and cold water lines, electrical boxes, eavestroughing and more recently, exterior siding. As of 1986, 51% of the Canadian siding market was supplied by vinyl siding (Modern Plastics, July 1987) indicating widespread consumer acceptance.

Plastic building materials were, and still are, subject to many problems caused by outdoor exposure to temperature variations, water, ozone, air pollutants and particularly ultraviolet radiation. These exposures can cause embrittlement, surface crazing, colour fading or chalking, environmental stress cracking, thermal fatigue and heat sagging. Development of new polymers and copolymers, improved additives and closer process controls have significantly reduced these effects making plastic building components economically attractive over a reasonable service life. Vinyl products have the longest service history at about 30 years.

Polymers that are both structural and weather-resistant tend to be more costly and compromises between price and service life are necessary. In the present case, the EWOC baseplate has been designed so that the more harmful effects of weather exposure, particularly ultraviolet light, are absorbed by the easily replaceable trim piece. Hence, a wider range of lower cost plastics are suitable for the baseplate manufacture.

3.2 Exterior Wall Opening Cover Baseplate

Acrylic-butadiene-styrene (ABS) is a common, readily available molding compound that has excellent injection molding characteristics. Its common use in residential construction is DWV pipe. Ultraviolet resistance is rated only fair (Modern Plastics Encyclopedia 1986 - 1987) but nevertheless, it is commonly used and has found general acceptance for outdoor products. In the present case, the baseplate is protected from direct sunlight exposure by the trim which is also anticipated to absorb most of the infrared portion of the light spectrum. Hence the ABS baseplate temperatures should be lower and therefore, less harmful. A high impact grade ABS, such as Borg-Warner GSM or equivalent, is recommended. A reasonable proportion of regrind material is acceptable which allows re-use of sprues and reject castings. Colours should be restricted to lighter shades – a gray similar to weatherproof covers for duplex receptacles or a beige is suggested.

A series of caulking compatibility tests are being conducted at the time of writing. Preliminary results indicate no difficulties. However, the test samples will be monitored further.

ABS dies can be manufactured from conventional, pre-hardened P-20 mold steels. Cost analysis indicates a two cavity mold is required to reduce the labour and injection machine costs to an acceptable level. Die inserts are recommended to permit one master die block to produce the entire range of EWOC fittings.

Polyvinyl chloride (PVC) was considered since it is relatively inexpensive, available from many resin suppliers, has good

outdoor exposure properties when properly formulated and has a long service history. Hot PVC is extremely corrosive and necessitates type 420 stainless steel die molds hardened to HRC 57 hardness levels. This would have approximately doubled the capital cost of the injection molding dies with little or no benefit in life expectancy.

3.3 Trim

The trim or "top hat" is recommended to be vacuum formed using PET (polyethylene terephthalate) sheet at 1.0 to 1.25 mm thickness (0.040 to 0.050 inches).

This material is tough, UV resistant (Modern Plastics Encyclopedia 1986 - 1987), relatively economical and should give a long service life. In any event, the design allows easy replacement of the top hat trim by the homeowner.

The PET is locally recycled from carbonated beverage containers. Virgin PET is an expensive material which finds use in higher cost applications for its strength and toughness as well as for its FDA acceptance for liquid food packaging. PET has excellent temperature resistance and is commonly employed for dual oven use (convection and microwave) in institutional or airline meal preparation.

3.4 Selection of Molding Methods

The original EWOC concept involved a complete vacuum formed shape. Vacuum forming uses simple molds and low cost

production equipment resulting in very economical production of simple shapes. However dimensional tolerances must be greater than for most other processes. A review of the EWOC design objectives and the inspection survey of construction practices related to electrical installations confirmed that the EWOC baseplate would require a shape too complex for vacuum forming and injection molding was selected. This allowed close dimensional tolerances and permitted a structurally rigid shape to be produced. The latter is necessary to bridge openings in the sheathing and to produce a frame for the cut siding edges.

Originally the EWOC was to be finished with conventional J-trim. However, current installation practices generally result in poor aesthetic appearances. Hence the EWOC was economically up-graded using the vacuum-formed top hat trim pieces.

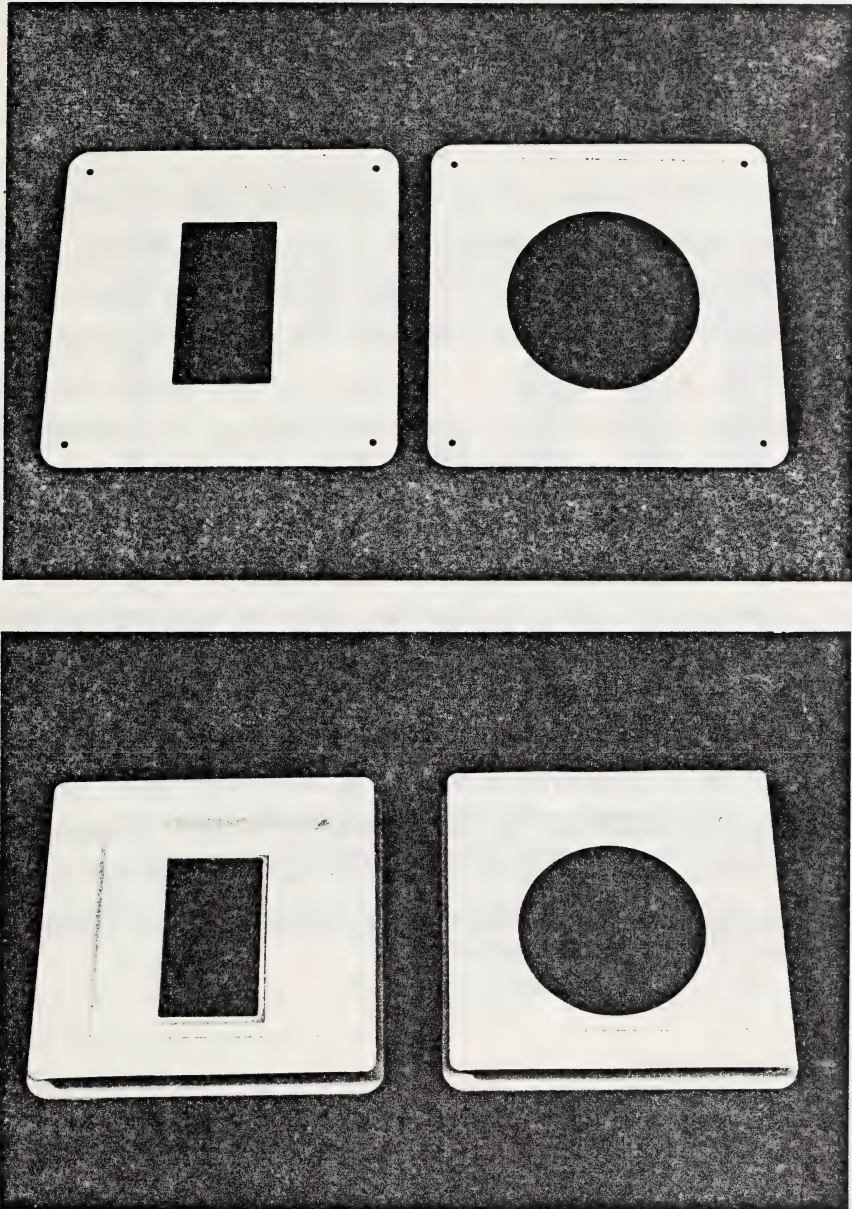


Figure 4: Photographs of ABS Base Flange

The ABS base plates injection molds have interchangeable die inserts so that a number of external openings may be accommodated with a single die. The vacuum formed PET trim pieces are similarly constructed to allow for duplex receptacles (left) and light fixtures (right).

4.0 AIR INFILTRATION TESTS

4.1 Test Methods

Complete details of the air infiltration test procedures and calculations are presented in Appendix 3. Briefly, the tests involved a simulated exterior wall with an exterior duplex electrical receptacle. A pressure differential was developed across the wall using a ducted fan to simulate air infiltration caused by temperature differentials and wind pressure. Air infiltration rates for various test conditions were measured for conventional and EWOC installations using an orifice plate and manometers. Test conditions included various pressure differentials, various plywood fits to the electrical box, effect of caulking and building paper. The reader is referred to the appendix for greater detail.

At the time of testing, production EWOCs were not available. Hence, a prototype EWOC was machined from solid PVC (polyvinyl chloride). Its dimensions and strength properties were similar to the production models and the infiltration test results are applicable to the injection molded production ABS EWOCs.

4.2 Test Results

Air infiltration testing on exterior duplex electrical outlets confirms that EWOC installations greatly reduce air infiltration rates over conventional practices. At low static pressure differentials that exist under normal conditions, the reduction is approximately an order of magnitude as illustrated in the bar graph (Figure 5). One might note that the quality of workmanship in the conventional

installations for these tests was far superior to commonly observed field practices.

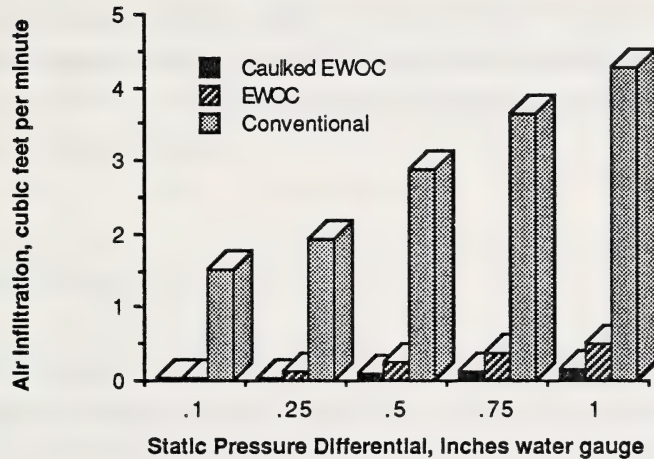


Figure 5: Bar Graph Showing Infiltration Losses

External wall opening cover fittings greatly reduce air infiltration as illustrated in this bar graph representation.

Note: Data below 0.7 inches water gauge for the EWOC and 0.25 inches for the conventional installation have been extrapolated from test results.

Caulked EWOC's resulted in the lowest infiltration rates which were generally about half that of uncaulked installations. While not entirely necessary, it is recommended that a bead of caulking be applied between the base plate and the sheathing. To this end the baseplate mold was engraved with a caulking guideline and instructions.

One interesting aspect of the infiltration tests is the high leakage rates of conventional electrical outlet installations that occur even under better than average workmanship.

Complete test results including test data documentation, calculations and plotted infiltration rates in linear and logarithmic formats are presented in Appendix 3.

5.0 MARKET RESEARCH

5.1 Purpose of the Research

The purpose of this research was threefold; to determine the market response to the product, to determine pricing levels and market share relationships, and to recommend an optimal pricing level for the product.

5.2 Methodology

As the exterior wall opening cover is a new concept in the market place, no comparable products exist. That is, it was impossible to compare consumer response to the exterior wall opening cover produced by Enduro Siding to the exterior wall opening cover produced by "Company Z".

It was necessary to elicit responses to a new method of finishing the openings in question, the electrical box and the lighting openings. The new method using the exterior wall opening covers is an additional cost to the user as opposed to a similarly priced alternative. To ensure the clarity of questions, a pretest was performed with three revisions.

The research consisted of three parts. The first two involved personal interviews. These provided information for conjoint analysis, and the market and problem identification. The third part involved a mail-out survey to the members of the Canadian Home Builders' Association.

A feasibility study conducted during an earlier phase of the product development had indicated that several attributes may be influential in the purchasing decision. It was deemed important to monitor the reaction to these attributes, relative to each other, since it was not possible to measure their significance against a non-existent competitive product.

Conjoint analysis provided a model and a measurement procedure that would provide market share projections by analyzing information such as utility of product attributes, relative value of each attribute, and the most desirable level of each attribute. As the model focuses on individual behavior, it was possible to predict population behavior to the extent that the sample individuals were representative of the population. It also allows the determination of the product attribute combinations that should be offered.

The conjoint model used the following formulation:

$$U(X) = U_1(x_1) + U_2(x_2) + \dots + U_i(x_i)$$

where x = level of each attribute (factor)

X = a bundle/package of attributes

$U_i(x_i)$ = partial utility function related to attribute i

Color of the J trim insert piece was offered in white only, white and beige, and white beige and brown combinations. These colors were chosen as a result of the feasibility study, which indicated them to be the most widely used trim color as well as the most commonly available and used aluminum fascia and soffit colors.

Color of the exterior wall opening cover, which is the piece placed directly on the building sheathing and then covered by the siding and/or the J trim insert, was included despite its relative insignificance. These parts were included in the conjoint analysis for two reasons. First, these parts must be produced and are essentially the backbone of this finishing system. Secondly, the research design allowed for the inclusion of an additional factor without increasing the number of attribute bundles that the respondents were required to rank.

The second part of the research was designed to gain information on the home building and renovation industry, focussing on the City of Edmonton. Information relative to size was difficult to achieve due to the dynamics of the industry. Number of employees was ruled out due to the industry practice of contracting/hiring on a need basis. The size of a company may swing dramatically from the two or three key personnel to 20+, depending on the number of crews hired for specific peak periods. Likewise, annual sales were impractical due to the presence of companies which engage in more than home building or renovation activities. A single industrial or commercial project could easily sway the earnings of a company without impacting on the number of residences built by the company.

As inherent limitations were present in the two measures outlined, it was decided that the number of residential structures built or sided by the companies interviewed would be the best indicator of the role played by the company in the market place. This measure also has its limitations as it could not be compared to secondary data in order to derive other market characteristics.

Sample selection was originally designed on a random basis. Further, it was determined that those companies which had participated in any way with the feasibility study previously conducted would not be recontacted in order to reduce bias and to simulate a more natural, single exposure to the product. This reduced the available population numbers by 10.

The Contacts Influential 1986 was used as a source of single family housing construction representatives. Lacking other alternatives, The Edmonton Yellow Pages was used as a listing for the siders. Each listing was numbered and random numbers were generated to select a sample of size thirty. Unfortunately, both of these listings are dated by their nature and therefore not terribly accurate. Due to the reluctance to participate in the research, absence of company representatives most suited to comment on the product, and business failure/closure (53% of the original sample), only five participants were selected in the initial attempt.

Replacement was initially done on a random basis. However, when this resulted in a similar participation rate as previously indicated, a convenience sampling method was adopted. Further, companies were asked to estimate the breakdown of the industry in terms of size and role of industry representatives. As with any industry, there are both large and small producers as well as up and down scale producers. This type of information was not available from secondary data sources.

Initial population size was estimated at 203 siders and builders in Edmonton. This was subsequently revised to 184 based on the telephone directory. Of these, 89 (excluding those previously contacted) were contacted to participate in this

study and 28 agreed to view the product, to give their opinion, and to participate in the research.

Unfortunately, only 24 participants were willing to participate within the time lines set out for the research, partly because of the Edmonton Tornado which meant increased work levels for many companies. Attempts to schedule interviews on the weekends or evenings, or to deliver questionnaire material for subsequent pickup or telephone response (depending on the preference of the subject) were not successful. The actual completed responses totalled 24.

The third part of the research focussed on the nationwide acceptance of the product. As other geographical areas could not be personally canvassed, a mailout survey was sent to 35 provincial, government and technical associate members of the Canadian Home Builders' Association. It was assumed that each member would be aware of specific factors in each region that would influence the acceptance of the product. In each case, the respondent was asked to comment on the method most commonly used to finish these openings in their regions, their opinion of perceived attractiveness, labour efficiency and energy efficiency of the method indicated, as well as the estimated number of builders and renovators who would use the product. The representatives were considered to be industry experts, given their membership at the national level.

The original time frame set out for the research was 5 weeks, with interviews and mailout responses to be concluded between August 1 and August 31, 1987. The results interpretation was scheduled for

the week of September 1. This time frame was extended to September 7, 1987 in order to elicit full participation by the sample members without success.

5.3 Results

5.3.1 Conjoint Analysis

Conjoint analysis is a complex analytical approach. For that reason, explanation of the approach has been omitted. The following section focuses on a summary of interviewee responses.

A weighting was attached to each interviewee's responses in relationship to his representation of the market. Representation was determined by the number of residential structures each builder was responsible for in 1986. For example, if a builder was responsible for 2% of the homes built in that year, he would represent 2% of the market and his responses were weighted accordingly. Due to rounding, the totals do not necessarily sum to 100%. The results are presented in Table 1 on the following page.

Table 1: Attribute Rankings in Decision Making Process

Primary Importance

	% Positive		% Positive	
	<u>% Builders</u>	<u>Builders</u>	<u>% Siders</u>	<u>Siders</u>
Price	76	73	68	49
EWOC Base Color	1	1	5	8
J Trim Insert Color	3	4	27	43
Brand Name	21	22	0	0

Secondary Importance

Price	4	1	5	8
EWOC Base Color	12	15	9	0
J Trim Insert	68	64	58	92
Brand Name	16	20	28	0

Eighty-two percent of the builder respondents were positively inclined toward the product, indicating that they would purchase it at a price which they felt was reasonable. An additional 13% of the group indicated that they would use it if the siders that they contracted advised the use of this product.

Seventy-six percent of the total builders indicated that price played the major role in their decision to purchase the product. Of the subsample which indicated a preference to purchase the product, 73% indicated that price was the single most important factor in their decision making process.

One percent of the positive subgroup indicated that the color of the exterior wall opening cover (the base unit) was the most important

to their purchasing decision. This converts to less than one percent of the total sample of builders.

Four percent of the positive group of builders indicated that color of the J trim insert was the most important to their decision. This is three percent of the total sample.

Twenty-one percent of the builders sample indicated that the brand name was the most significant factor in the decision making process. This represents 22% of the positive subsample.

The siding applicators were separated from the sample group. The size of this group, for reasons indicated earlier, prevents the information from being representative of the market place. It does, however, provide indications of the acceptance level of the group.

Sixty-three percent of the siders sample indicated a positive response to purchasing the product. Forty-nine percent of the positive respondents indicated that price was the predominant factor in their decision making process. Of the total group, 68% indicated that price was the biggest factor in determining the purchase of the product, or not. Interestingly, the siders appeared more interested in the J trim insert than did the builders. Twenty-seven percent of the siders indicated that the color offerings were of primary importance in their decision making process. Of the subgroup indicating a preference to purchase the product, 43% ranked the J trim insert color offerings as the primary factor in their choice to purchase.

None of the siders indicated that brand name was the primary factor in their choice to purchase or not to purchase the product. The base unit color was of primary importance to only 5% of the entire group and 8% of the positive subgroup.

As the attribute ranking as second most important in the decision making process, color of the J trim insert was chosen by the majority of the builders regardless of their purchase decision. This represents 68% of the sample and 64% of the positive sub group. This was followed by brand name, where 16% of the market indicated it was of secondary importance which corresponds to 20% of the positive subgroup. Color of the EWOC base was indicated as being of secondary importance to 12% of the builders and 15% of the positive builders subgroup. Price was the second consideration to only 4% of the builders and 1% of the positive subgroup of builders.

The siders overwhelmingly (58%) chose J trim color as the factor second most important in their purchasing decision. This represents 92% of the positive subsample.

Brand name was ranked by 28% of the total siding group, whereas none of the positive subsample indicated that this was of secondary importance.

Eight percent of the positive subgroup ranked price as the second most important factor of the purchasing decision, with 0% of this group attaching any significance to the EWOC base color. Of the total siders group, these attributes were ranked as secondary in importance by 5% and 9% respectively.

The responses of the positive subgroups are of greater importance than that of the total samples, because they are predisposed to purchase the product. The builders place more significance on brand name than do the siders, but both groups' primary factor in the decision making process was price.

The focus now shifts to the preference shown toward each of the factor levels. Due to the indifference showed between the significance attached to some of the levels, tied rankings were not included in the following discussion. This results in some totals summing to less than 100%.

Table 2: Attribute Level Preference (Selected Attributes)

	%Builders	% Siders
<u>Price</u>		
\$1.99	77	95
\$2.99	23	5
\$4.49	0	0
<u>J Trin Insert</u>		
White	9	9
White/beige	0	31
White/Beige/Brown	81	51
<u>EWOC Base Color</u>		
White	40	36
Beige	5	36
Grey	28	0

As expected, \$1.99 was the most preferred pricing level by the majority of the builders (77%) and the siders (95%). The second option of \$2.99 was most preferred by 23% and 5% of each group respectively. This indicated an upper limit in terms of pricing acceptability.

The J trim insert color option most preferred was the white, beige and brown combination, chosen by 81% of the builders and 51% of the siders. Further, it appears that offering a white and

beige combination is less attractive to the builders than offering the product in white only. That is, the product should be offered in the three colours or in white only. Remembering that the EWOC base color was of relatively little importance in the decision making process, 40% of the builders chose white, 5% beige and 28% grey. The sidlers ranked the options as 36% white, 26% grey and 0% grey. This leaves 27% and 23% of each group indicating an indifference to the color option of the base unit. Verbal response to this issue indicated that if the base units were packaged separately from the J trim inserts, white would be the most preferred alternative for the base unit. Alternately, if the J trim insert and EWOC base were packaged together, then both pieces should be identical in color.

The internal validity of the information provided is consistent with the high results typical of conjoint analysis. For example, the predicted and actual ranking scores of three companies for each bundle offered in the survey are shown in Table 3. The reader will note the accuracy of the predicted rankings.

Table 3: Internal Validity

Company 1-Detail	Company 1		Company 2		Company 3	
	Predicted	Actual	Predicted	Actual	Predicted	Actual
	<u>Rank</u>	<u>Rank</u>	<u>Rank</u>	<u>Rank</u>	<u>Rank</u>	<u>Rank</u>
XP = $1.0+.62+.51+.39=2.52$	8	8	3	3	9	9
XO = $.51+.51+.39+.62=2.03$	5	5	5	5	5	5
XU = $.01+.51+.51+.51=1.54$	2	2	7	7	2	2
XY = $1.0+.56+.51+.62=2.69$	9	9	8	8	8	8
XT = $.51+.56+.62+.51=2.2$	6	6	6	6	4	4
XR = $.01+.56+.39+.39=1.35$	1	1	2	2	1	1
XE = $1.0+.45+.39+.51=3.7$	7	7	9	9	3	3
XW = $.51+.45+.39+.39=1.74$	4	4	4	4	3	3
XQ = $.01+.45+.51+.62=3.3$	3	3	1	1	7	7

In summary, the responses provided by the interviewees, in conjunction with the modified conjoint analysis, provided for an accurate assessment of the preferences and response to the product of these market representatives.

5.3.2 National Responses

The response given by the Canadian Home Builders' Association representatives indicated a positive market response to the product, although not to the same degree indicated by the Edmonton area survey. This could be partially due to the format of the questionnaire; mail-out versus a personally administered questionnaire.

Responses were not returned for all of the areas, yet a strong response was received from the Ontario region which was of primary concern for the inventor.

The province of Alberta was assumed comparable to the Manitoba/Saskatchewan region, as was Ontario to British Columbia and Quebec, where humidity levels and presence of brick facing is common. The percentages shown below are the projections (averaged projections for multiple responses) made by the industry experts in each region. The provincial groupings used in the feasibility study have been retained here.

Table 4: Summary of Survey Responses: Canada

	<u>Atlantic</u>	<u>Ont./Que.</u>	<u>Man./Sask</u>	<u>Alberta</u>	<u>B.C.</u>
% Builders	65	32.5	80	80	32.5
% New Const.	72.5	38	82	82	38
% Renovators	75	44	80	80	44
% Renov. Wk.	55	34	63	63	43

5.3.3 Market Description and Problem

Ninety-five percent of the Edmonton sample indicated that caulking was the standard method of finishing these openings. An additional 2% used pressure foam in conjunction with the caulking. Surprisingly, 3% indicated that they used no sealant of any type when finishing these openings.

The cost of finishing these openings could not be estimated by one third of the builders. Using the estimates that were provided, it appears that \$1.50 is the average amount spent per opening.

Eighty-four percent of the builders described the current finishing methods as at least moderately detracting, with 31% of siders indicating likewise. Note, surprisingly, that given their predominant role in finishing these openings, 69% of the siders did not consider the current method detracting from the general appearance of the home.

The actual finishing of these openings was ranked as “not time consuming” by 91% of the siders and 32% of the builders. The majority of builders and siders (92% and 63%) thought that these openings were at least moderately important to the energy efficiency of the home.

Purchasing materials for these openings was performed by 100% of the siders surveyed. Sixty-five percent of the builders surveyed indicated that the tradesman, as opposed to the company, purchases these materials. All of the builders indicated that they contracted for material and labour for electrical work.

The respondents for all regions in Canada indicated that caulking was the current method used, occasionally with J trim. Additionally, all indicated that it was at least moderately detracting and moderately time consuming. The effect of these openings on the energy efficiency of the home was considered to be at least moderately important to all of the respondents, with 63% ranking it as very important.

In summary, there appears to be dissatisfaction amongst the builders, in the “product” that they receive from the siders. Interestingly, some builders from the Edmonton area indicated that they attempted to build frames for use under the lighting fixtures because of the lack of products on the market which address the deficiency in current finishing methods. Labour efficiency of the EWOC would be a poor promotional feature for the siding target market. The energy efficiency aspect is a general concern throughout the home building industry.

All of the builders carry on operations in Alberta, with 13% being active in Manitoba and 1% with activities in Ontario. None of the builders have been in business for less than two years, 35% had been operating for three to five years, 6% for five to ten years and 58% for more than ten years. It appears that those companies which attempted to start up in the last few years were unsuccessful, as was indicated by the difficulty experienced in the sample selection process.

The siders all concentrated on local work, with 9% venturing to Ontario for at least part of that provinces peak period. None of the siding group had been in business for less than 5 years with 18% of the group having operated for more than 10 years.

5.4 Interpretation of Data Analysis

Overall, price of the units and J trim color were the most significant factors in the decision making process. Potential purchasers were more sensitive to price than to the color options of the J trim, brand name and color of the EWOC base respectively.

The three price levels were rescaled for the individual respondents to determine price sensitivity. Market share drops off relatively slowly as the price level rises from \$1.99 to \$2.99; however, it drops off rapidly after this level. Response to a \$2.49 level was interpolated in order to allow comparison for levels other than indicated in the questionnaire. The following graph represents the relationship for the Edmonton area.

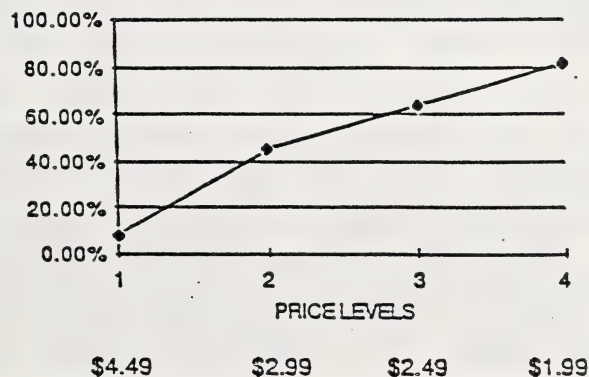


Figure 6: Market Share/Price Relationship

Color of the J trim insert is most attractive with the three color options, followed by white only. That is, it is preferable to offer this piece in white, beige and brown or in white alone, than to offer a white and beige color option. The greatest percentage of all groups ranked this option as second most important in their decision to purchase. Further, it is unlikely that more than these three basic colors could be offered by any manufacturer, due to the problem of matching the color tones exactly with the sidings. Each of the major siding manufacturers would face the same problem when attempting to sell matching units to contractors which do not purchase their brand of siding. In summary, white, beige and brown are the color options determined to be the most demanded.

5.4.1 Market Projections

Four pricing levels were considered in determining market share. It was assumed that three color options of J trim insert would be offered due to the survey indications.

The pricing sensitivity was assumed to be constant across all regions. Further, it was assumed that the market percentages, indicated by the local survey and the national responses at the lowest price offered (\$1.99), represents the maximum number of purchasers. For example, since only 82% of the Alberta builders indicated any inclination to purchase the product at a price that they thought was reasonable, it was not assumed that reducing the price to, for example, \$1.49 would induce any more than 82% of the market. The portion of the market not indicating a preference to the product and/or those indicated by the industry experts, as non-purchasers, were excluded from the survey pricing sensitivity analysis.

Market share for the pricing levels of \$1.99, \$2.99 and \$4.49 were measured directly in the conjoint analysis. Market share for the \$2.49 level was interpolated. Total potential market was derived from the previous feasibility study, based on the construction activity in each province multiplied by the number of units required for houses, duplexes and townhouses. Industrial and commercial construction levels were excluded. Detailed estimates of the market potential of the product were viewed as proprietary and are therefore excluded from this report.

The study also estimated company profits for alternate price levels and market presentations. However, much of the work leading to these estimates is also considered proprietary and is therefore not documented in this report.

5.5 Market Research Conclusion*

The research has been successful in determining the market response to the product. It is much more positive than the information gathered during the feasibility study indicated.

Entry strategy is the key to the success of a new product. The actual market share gained will depend on the product offerings, particularly price and the color of the J trim insert.

It is recommended that a price level be set at \$2.99 per unit. Competitive reaction is difficult to predict and the added range of maneuverability is attractive. The full range of color options should be offered for the J trim insert. Depending on the packaging decided upon, the EWOC base should be white or should match the J trim inset.

Note:* Market research is a tool to decision making. The information provided will assist the inventor in deciding on a course of action, but will not make the decisions for him. As such, no responsibility is assumed by M.A.I. or the researcher, Marsha Littlefair.

6.0 PROJECT CONCLUSIONS

Current established practices for the installation and finishing of penetrations through the exterior weather envelope frequently result in two problems; namely, a high probability of air, water, dirt or insect infiltration and difficulties in producing an aesthetic finish. These arise from workmanship and the lack of suitable fittings to assist in finishing.

Both of these problems are addressed by the EWOC in a simple, straightforward and cost-effective manner. Design of the baseplate allows effective sealing of the outer weather envelope while accommodating wide variations in the workmanship of the sheathing opening. The raised web allows efficient trimming and fitting of the exterior cladding to the opening while the slide-in tophat trim piece creates a consistent professional finished appearance. A smooth rigid surface to seal against is created regardless of the exterior finish.

A wide variety of exterior envelope penetrations are accommodated in a common fashion. Thus the EWOC represents an excellent opportunity to provide a standardized method of preparing and finishing such penetrations. A major benefit will be a reduction of labour costs and co-ordination problems between trades while increasing the quality of the finished product.

A long useful life for the EWOC is projected due to the use of UV resistant PET tophat trim pieces which are readily replaceable in the advent of damage.

Air infiltration testing has confirmed that EWOC installations result in significant reductions compared to conventional methods. In fact, the EWOC produces an essentially air-tight exterior envelope penetration when used with a gasket and electrical cover plate. Dirt, water and insect infiltration will also be largely eliminated.

EWOC installations will contribute to increased energy efficiency and structural longevity of new and renovated housing.

Market research suggests a positive response to the product and a sizeable market penetration can be achieved. The product acceptance was found to be in part, related to the product price. Production EWOCs have been priced according to those projections and it is anticipated that the market share will develop.

APPENDIX 1

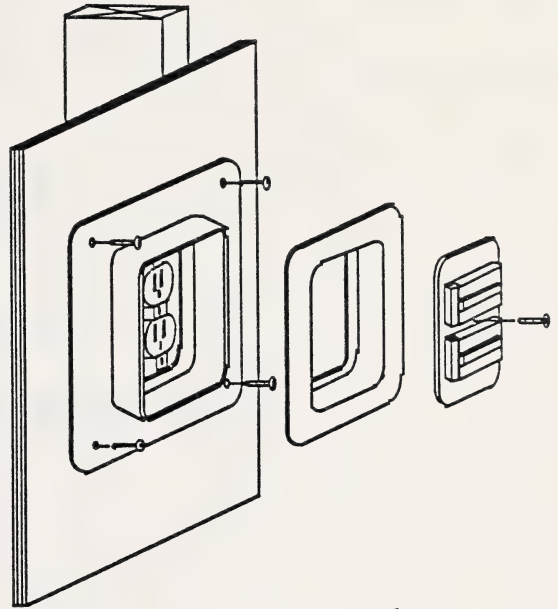
EXTERIOR WALL OPENING COVER INSTALLATION INSTRUCTIONS

EXTERIOR WALL OPENING COVER

manufactured by

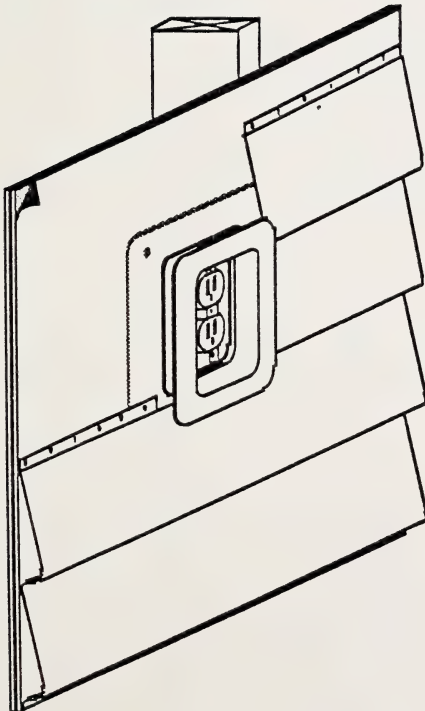
NEW PHOENIX
MANUFACTURING INC.

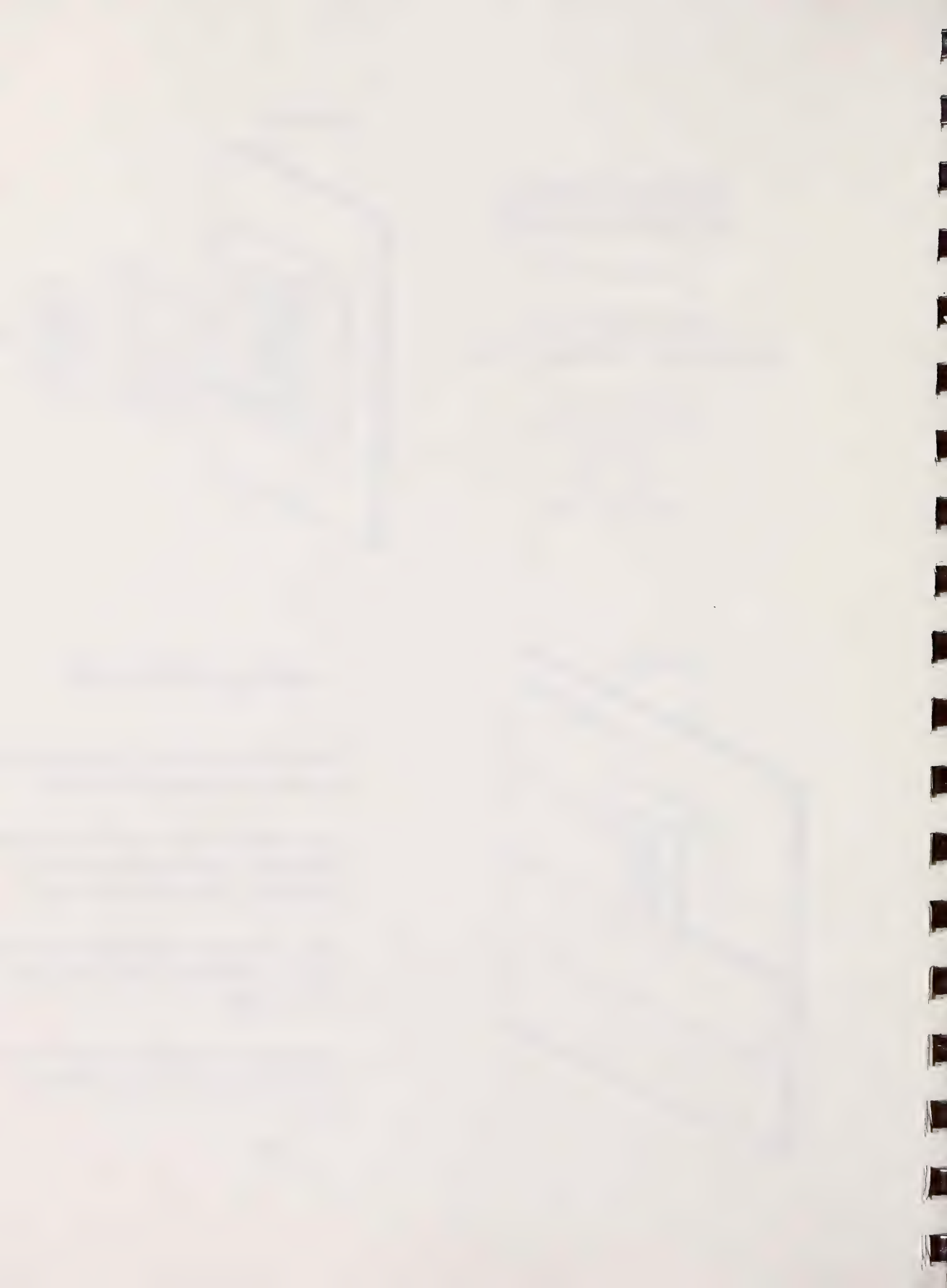
8826-93 Avenue
Fort Saskatchewan
Alberta
T8L 1A9
(403) 992-1677



INSTALLATION PROCEDURE

1. Mount the outlet box to the stud so that the box is flush with the sheathing surface.
2. Apply caulking to line on rear of base flange and attach to sheathing with screws or shingle nails, using the holes provided.
3. Apply building paper and exterior wall finish such as vinyl, wood or metal siding, stucco or brick veneer.
4. To complete the installation, install the top hat trim piece and weather proof outlet cover.





APPENDIX 2

NEW PHOENIX PROMOTIONAL LITERATURE

NEW PHOENIX MANUFACTURING INC.

proudly presents the first member of the EWOC family.

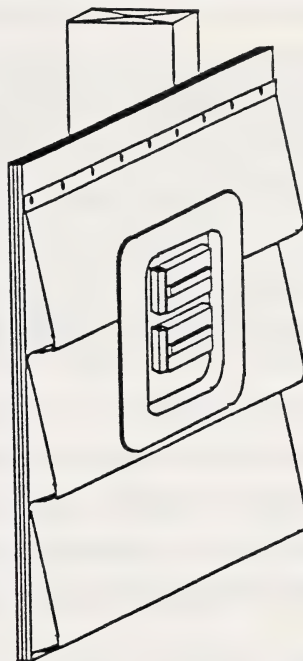
Providing----

- elimination of air, water, dirt and insect infiltration;
- increased labour efficiency; and
- professionally finished appearance.

---- for penetrations through the exterior membrane in frame construction.

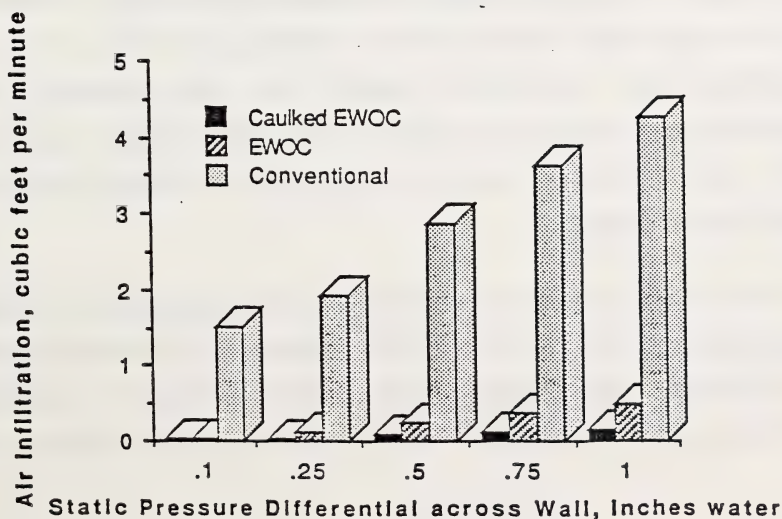
For additional information contact:

NEW PHOENIX MANUFACTURING INC.
8826-93 Avenue
Fort Saskatchewan, Alberta
T8L 1A9
(403) 992-1677



*Exterior duplex electrical receptacle
using an EWOC fitting.*

Air Infiltration Test Data



An average residence has many necessary penetrations in the exterior weather envelope for fixtures and services. In recent years, generally increasing living standards have greatly increased their numbers to include electrical outlets and light fixtures, dryer and cooking vents, fresh air intakes for furnaces and fireplaces, electricity service entrances and water and gas outlets. Exterior finishes, such as siding or stucco, must fit neatly to these openings not only for appearance but also to minimize infiltration of air, dirt or water into the wall cavity. Until now the lack of suitable fittings or covers made this difficult to accomplish.

Current practices for the installation and finishing of penetrations through the exterior weather envelope frequently result in two problems; namely a high probability of air, water, dirt or insect infiltration and difficulties in producing an aesthetic finish. These arise from workmanship and the lack of suitable fittings to assist in finishing.

Both of these problems are addressed by the New Phoenix injection molded plastic EWOC fitting in a simple, straight-forward and cost effective manner. A smooth, structurally rigid baseplate allows effective sealing of the outer weather envelope while accommodating wide variations in the workmanship of the sheathing opening. A frame formed by the raised web allows efficient trimming and fitting of the exterior cladding while the slide-in "tophat" trim piece instantly creates a professionally finished appearance. One EWOC design accommodates vinyl, metal and wood siding, or stucco exterior finishes thereby reducing the builder's inventory.

A wide variety of exterior envelope penetrations are accommodated in a common fashion. Thus the EWOC represents an excellent opportunity for builders to standardize on a cost effective method of preparing and finishing such penetrations. A major benefit is the reduction of labour

costs and co-ordination problems between trades while increasing the quality of the finished product.

Air infiltration testing under controlled laboratory conditions has confirmed that New Phoenix EWOC fittings result in significant reductions compared to conventional methods. In fact, the EWOC produces an essentially air-tight exterior envelope penetration as shown in the accompanying chart. Dirt, water and insect infiltration are also eliminated. Hence New Phoenix EWOC installations contribute to the increased energy efficiency and structural longevity of new and renovated housing.

APPENDIX 3

AIR INFILTRATION DATA

A3.0 AIR INFILTRATION DATA

A3.1 Test Apparatus

The test apparatus, shown in Figure A1, consisted of a simulated exterior wall section connected to a suction fan by 100 mm (4 inch) plastic ducting. The pressure drop across a square-edged orifice plate located at the ducting's mid point allows calculation of the air flow leakage. Various static pressures can be created across the test wall by throttling the fan using plastic covers on the Y-fitting.

An exterior wall was simulated with 2 x 4 framing covered by 19 and 6 mm (3/4 and 5/16 inch) plywood on the rear and front respectively. An electrical box was mounted to a stud with its face flush with the exterior surface of the 5/16 inch spruce sheathing grade plywood. Stud spacing was 600 mm (24 inches) on centre so that any sheathing deflections due to static pressure would affect the air infiltration through the duplex receptacle and coverplate in a manner similar to an actual wall. The test frame was assembled using screws with caulking between all mating surfaces. After assembly, additional acrylic caulking was applied to make the unit as air-tight as possible.

A square-edged orifice plate with a 12.85 mm (0.506 inch) orifice diameter was placed at the mid-point of the 3.65 m (12 foot) ducting run. Pressure taps on either side allowed precise differential pressure measurement through use of an inclined manometer. A second tap downstream of the orifice allowed measurement of the absolute pressure for air density adjustment

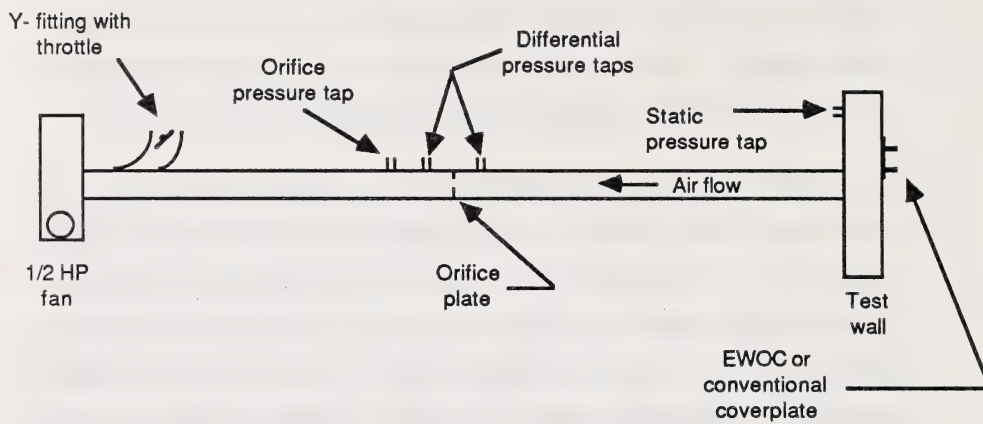


Figure A1: Air Infiltration Test Apparatus Layout

Test apparatus layout for determination of air infiltration through the external wall opening cover and for conventional exterior wall penetrations.

calculations. A pressure tap on the back of the test wall allowed determination of the static pressure at the EWOC.

The more critical orifice pressure differential was measured using a Dwyer model 424 manometer which is graduated in the 0 to 2 inch water gauge range at 0.01 inch increments and in the 2 to 10 inch range at 0.1 inch increments. The length of the 0 to 2 inch range is 20 inches allowing accurate interpolation to 0.001 inches water gauge. The static pressure at the test wall and the absolute pressure downstream of the orifice were measured with a Dwyer model 400 with the 0 to 1 inch range (6 1/2 inches length) having marked increments of 0.01 inches water gauge and the 1 to 10 inches having 0.1 inch increments.

The duct joints were taped with duct tape and the fan housing was caulked with silicone caulking. A 1/2 horsepower fan was used with variations in suction pressure accomplished by placing plastic covers with varying hole sizes over the Y-fitting's entrance.

A3.2 Exterior Wall Opening Cover Test Specimens

A prototype EWOC was machined from solid polyvinylchloride plate material according to the dimensions on the final engineering drawings for the production EWOC's. Preliminary air infiltration testing confirmed that the stiffness provided by the raised web was necessary to resist deflection by pressure differentials across the test wall. The machined prototype was also used during the market survey reported elsewhere.

A3.3 Test Procedures

Air leakage through conventionally finished and EWOC equipped electrical outlets was measured under a series of conditions. These were:

- varying sheathing hole sizes and quality of fit to the electrical box;
- mounting of the EWOC or conventional cover plate directly on plywood or over top of building paper;
- use of metal and plastic weatherproof coverplates;
- use of caulking or gaskets between EWOC and the sheathing; and
- varying the static pressure at the EWOC from 0 to 4.3 inches water gauge.

Four sizes of sheathing holes were employed having gradually increasing areas of 6.61, 8.44, 10.12 and 10.88 square inches. The foam gasket for the weatherproof coverplates covered all openings except for the last which had a 1/16 inch opening along one vertical side.

Each configuration was tested at 15 static pressures created by covering the Y-fitting's intake with coverplates having different open areas. The leakage was measured under negative pressure differentials for all test runs, that is, the interior of the simulated wall was at lower pressure than atmospheric. Prior to the test runs, considerable effort was expended to seal the apparatus. The smallest hole for the electrical box had already been cut in the

sheathing. During the apparatus leakage measurements, the hole was covered with caulked plastic sheeting. Despite these attempts the apparatus air leakage could not be reduced to zero. A plot of apparatus leakage for various static pressures is given in Figure A2. It will be seen in the test results that a caulked EWOC sealed the apparatus better than the plastic sheeting.

Air flow past the orifice plate (that is, the leakage through the exterior wall opening) was calculated using the following expression.

$$Q_m = C A_2 \sqrt{\frac{2g \cdot 62.4 W_m h_o}{12 \left[1 - \left[\frac{d_2}{d_1} \right]^4 \right]}} \frac{60}{W_m}$$

where Q_m = flow, feet³/minute

A_2 = orifice area, feet²

C = discharge coefficient

W_m = air density at meter, pounds/feet³

d_1 = pipe inside diameter, inches

d_2 = orifice diameter, inches

g = gravity

h_o = pressure differential at orifice, inches water gauge

Trial calculations indicated that corrections to the air density at the orifice (W_m) were much less than the experimental error. Hence

0.07 lb/ft³ was used as the air density throughout the testing and measurement of the absolute pressure at the orifice plate was discontinued.

A3.4 Test Results

A listing of the various configurations used in the air infiltration testing are presented in Table A1. Some measured values for the pressure drops and static pressures along with the air flow rate are given at the back of Appendix 3.

Test	Description
1	Apparatus leakage with original opening using 10 throttle plates.
2	Apparatus leakage with original opening using 15 throttle plates.
3	Plastic W/P cover over building paper with original opening.
4	Plastic W/P cover directly on plywood with original opening.
5	EWOC with plastic W/P cover and building paper with original opening.
6	Caulked EWOC with plastic W/P cover and building paper with original opening.
7	Retest of apparatus leakage with original opening using caulked plastic.
8	Plastic W/P cover directly on plywood with 2.25" x 3.75" opening.
9	EWOC with plastic W/P cover with 2.25" x 3.75" opening.
10	Metal W/P cover directly on plywood with 2.38" x 4.25" opening.
11	EWOC with metal W/P cover with 2.38" x 4.25" opening.
12	Metal W/P cover directly on plywood with 2.56" x 4.25" opening.
13	EWOC with metal W/P cover with 2.56" x 4.25" opening.
14	Caulked EWOC with metal W/P cover with 2.56" x 4.25" opening.

Table A1: Description of Air Infiltration Test Runs

Since it was not possible to completely seal the apparatus, some baseline leakage existed. For this reason leakage for the various external wall opening configurations are compared to this baseline leakage value. Air infiltration flow rates are presented in Figures A2 and A3 as a function of static pressure differential across the simulated wall section. In practice, this pressure differential would be caused and affected by inside and outside temperature differentials, wind velocity, location in the structure relative to ground level and to wind direction and the operation of appliances such as furnaces, fireplaces and exhaust fans.

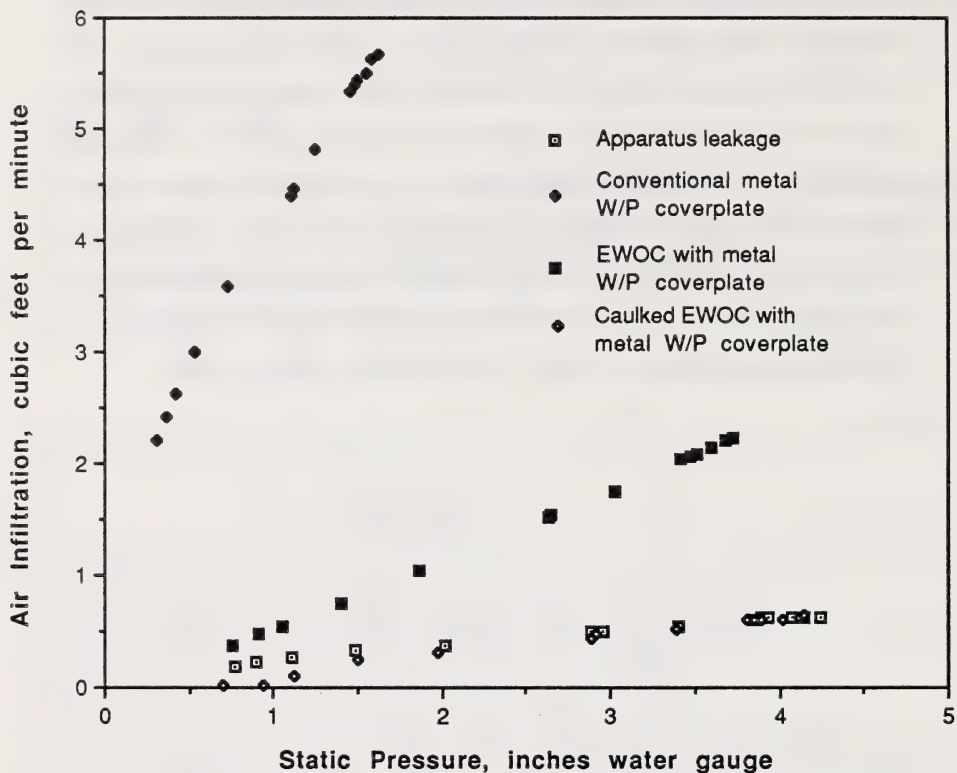


Figure A2: Air Infiltration and Static Pressure, Linear Scale

Air infiltration rates plotted against static pressures for conventional, EWOC and caulked EWOC installations compared to the test apparatus base leakage rates. Metal weatherproof cover plates were used for these tests. Note the very large reduction in air infiltration rates for the EWOC installations. A gasket or caulking applied between the sheathing and the EWOC reduced the infiltration rate to apparatus leakage values.

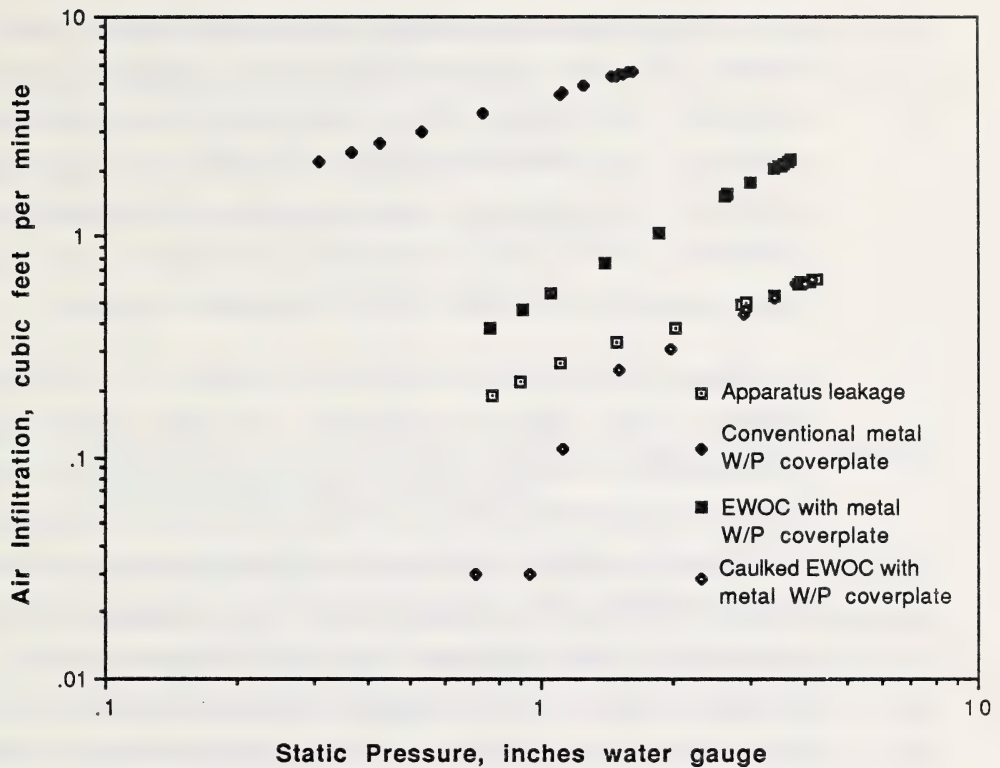


Figure A3: Air Infiltration and Static Pressure, Log Scale

Air leakage through conventional and EWOC installed exterior outlets as a function of static pressure plotted on a logarithmic scale. The infiltration rate takes the form $Q = Kh_0^n$ which represents a straight line when plotted logarithmically. The three low pressure values for the caulked EWOC are non-linear because the leakage rates were below the test method's lower measurement limit.

Figures A2 and A3 plot (on linear and on logarithmic scales, respectively) air leakage rates from test runs 7, 12, 13 and 14 which are, in order; leakages due to the baseline apparatus, a good quality conventional installation, an external wall opening

cover installation and an EWOC installation with a bead of caulking between the EWOC baseplate perimeter and the sheathing. In all cases, a metal weatherproof cover plate was employed. Both EWOC installations provided very significant reductions in air infiltration rates compared to the conventional installation. At low pressure differentials (less than 1 inch water gauge), the reduction was an order of magnitude or greater.

In general, air infiltration rates Q as a function of differential pressure, ΔP will follow the relationship $Q = K\Delta P^n$ where K is a proportionality constant, and n is the exponent of flow. When plotted on a logarithmic scale, a straight line results as is the case in Figure A3 except for the three lowest pressure readings for the caulked EWOC. This validates the air flow leakage calculation employed or, more properly, that the Reynolds number (a characteristic of fluid flow) through the orifice was large enough to ensure that the orifice discharge coefficient was a constant except for the three lowest readings for the caulked EWOC. The actual leakage rates for those points are slightly understated.

The equations for air flow leakage rates under the present test conditions plotted in Figure A3 are:

$$Q = 0.24 \Delta P^{0.68} \text{ (apparatus)}$$

$$Q = 4.28 \Delta P^{0.57} \text{ (conventional)}$$

$$Q = 0.52 \Delta P^{1.10} \text{ (EWOC)}$$

$$Q = 0.17 \Delta P^{0.94} \text{ (caulked EWOC)}$$

where flow, Q, is in cubic feet per minute and the static pressure differential is in inches water gauge.

Air flow leakages through the EWOC assembly did not vary significantly with the hole size in the sheathing. The basic leakage path was between the baseplate and the sheathing due to sheathing surface irregularities. A bead of caulking on the sheathing around the opening effectively sealed the EWOC and reduced leakages at lower static pressure differentials to below the apparatus measurement capabilities. A thin foam gasket would be as effective.

Air flow through the conventionally installed openings depended essentially on the seal between the weatherproof coverplate and the sheathing effected by compression of the foam gasket. When installed directly against the plywood, the air leakage was minimal, approximately that of an uncaulked EWOC. Airflow leakages increased to levels slightly greater than on uncaulked EWOCs when the weatherproof coverplate was installed over the building paper. One might note that the quality of workmanship in the conventional installation used in these tests was far superior to those noted in the field observations. If a gap existed beneath the

gasket or if the sheathing hole extended beyond the gasket, leakage rates increased by nearly an order of magnitude at a given static pressure. It became very clear during these tests that for conventional exterior electrical outlet installations where the box protrudes beyond the sheathing and where no flat, rigid and continuous sealing surface for the coverplate gasket exists, very large potential air infiltration sources will be created. Almost all of the exterior duplex electrical outlets observed in the field survey fell into this category.

As a side note, the metal weatherproof coverplate gave lower leakage rates than the plastic example. If the attachment screw was over tightened, the plastic body deflected causing a significant increase in the infiltration rate.

h_o is pressure drop across the orifice, inches water.

P orifice is the pressure downstream of the orifice, inches water.

Static P is the pressure at the EWOC test box, inches water.

Trial Number 3			Trial Number 4		
h_o	Static P	Flow	h_o	Static P	Flow
0.120	4.110	1.205	0.105	4.120	1.13
0.118	4.050	1.195	0.102	4.070	1.11
0.115	3.960	1.179	0.101	3.970	1.11
0.112	3.850	1.164	0.100	3.880	1.10
0.110	3.800	1.153	0.098	3.810	1.09
0.109	3.790	1.148	0.097	3.800	1.08
0.087	3.260	1.026	0.081	3.470	0.99
0.073	2.890	0.940	0.065	2.850	0.89
0.071	2.820	0.927	0.063	2.820	0.87
0.040	1.960	0.696	0.041	1.950	0.70
0.024	1.420	0.539	0.027	1.450	0.57
0.017	1.130	0.453	0.020	1.120	0.49
0.012	0.890	0.381	0.016	0.895	0.44
0.010	0.760	0.348	0.012	0.750	0.38
0.002	0.130	0.156	0.003	0.120	0.19

Trial Number 5			Trial Number 6		
h_o	Static P	Flow	h_o	Static P	Flow
0.195	4.020	1.54	0.092	4.130	1.05
0.192	3.950	1.52	0.091	4.070	1.05
0.185	3.850	1.50	0.090	4.030	1.04
0.181	3.750	1.48	0.088	3.850	1.03
0.179	3.720	1.47	0.085	3.820	1.01
0.174	3.700	1.45	0.083	3.780	1.00
0.146	3.250	1.33	0.070	3.350	0.92
0.122	2.840	1.21	0.056	2.940	0.82
0.118	2.750	1.19	0.053	2.840	0.80
0.070	1.950	0.92	0.034	2.050	0.64
0.043	1.430	0.72	0.021	1.450	0.50
0.027	0.995	0.57	0.012	1.100	0.38
0.023	0.938	0.53	0.011	0.947	0.36
0.016	0.740	0.44	0.008	0.798	0.31
0.001	0.125	0.11	0.001	0.120	0.11

Table A2: Pressure Drops and Calculated Air Infiltration for Trials 3 to 6

Trial Number 7			Trial Number 8				
h	o	Static P	Flow	h	o	Static P	Flow
0.033		4.240	0.63	0.069		4.180	0.91
0.033		4.140	0.63	0.065		4.120	0.89
0.032		4.080	0.62	0.063		4.020	0.87
0.032		3.940	0.62	0.061		3.910	0.86
0.032		3.900	0.62	0.060		3.870	0.85
0.031		3.850	0.61	0.059		3.850	0.84
0.024		3.400	0.54	0.044		3.400	0.73
0.021		2.950	0.50	0.034		2.950	0.64
0.020		2.880	0.49	0.032		2.870	0.63
0.012		2.020	0.38	0.020		2.000	0.49
0.009		1.480	0.33	0.011		1.480	0.36
0.006		1.100	0.27	0.006		1.180	0.27
0.004		0.895	0.22	0.005		0.975	0.25
0.003		0.772	0.19	0.002		0.740	0.16
0.001		0.105	0.08	0.000		0.125	0.03

Trial Number 9			Trial Number 10				
h	o	Static P	Flow	h	o	Static P	Flow
0.449		3.770	2.33	0.036		4.280	0.66
0.429		3.710	2.28	0.035		4.120	0.65
0.412		3.650	2.23	0.035		4.020	0.65
0.390		3.550	2.17	0.034		3.920	0.64
0.381		3.510	2.15	0.034		3.880	0.64
0.372		3.480	2.12	0.033		3.820	0.63
0.286		3.060	1.86	0.026		3.380	0.56
0.223		2.690	1.64	0.020		2.960	0.49
0.213		2.650	1.60	0.020		2.900	0.49
0.110		1.910	1.15	0.011		2.000	0.36
0.062		1.430	0.87	0.006		1.540	0.27
0.040		1.120	0.70	0.004		1.100	0.22
0.031		0.950	0.61	0.003		0.925	0.19
0.021		0.760	0.50	0.001		0.735	0.11
0.000		0.120	0.03				

Table A3: Pressure Drops and Calculated Air Infiltration for Trials 7 to 10.

Trial Number 11			Trial Number 12				
h	o	Static P	Flow	h	o	Static P	Flow
0.452		3.700	2.34	2.650		1.620	5.66
0.445		3.650	2.32	2.620		1.580	5.63
0.425		3.570	2.27	2.510		1.550	5.51
0.402		3.480	2.20	2.440		1.500	5.43
0.389		3.420	2.17	2.400		1.480	5.39
0.381		3.410	2.15	2.350		1.450	5.33
0.289		3.020	1.87	1.922		1.250	4.82
0.222		2.680	1.64	1.645		1.120	4.46
0.210		2.610	1.59	1.599		1.100	4.40
0.105		1.900	1.13	1.068		0.735	3.59
0.055		1.400	0.82	0.745		0.535	3.00
0.030		1.000	0.60	0.569		0.425	2.62
0.025		0.920	0.55	0.480		0.365	2.41
0.015		0.700	0.43	0.401		0.310	2.20
0.000		0.125	0.03	0.055		0.050	0.82

Trial Number 13			Trial Number 14				
h	o	Static P	Flow	h	o	Static P	Flow
0.408		3.730	2.22	0.034		4.150	0.64
0.402		3.690	2.20	0.033		4.120	0.63
0.382		3.600	2.15	0.031		4.020	0.61
0.360		3.520	2.09	0.031		3.890	0.61
0.355		3.480	2.07	0.030		3.850	0.60
0.348		3.420	2.05	0.030		3.810	0.60
0.255		3.020	1.76	0.022		3.390	0.52
0.198		2.650	1.55	0.018		2.920	0.47
0.194		2.640	1.53	0.016		2.890	0.44
0.090		1.860	1.04	0.008		1.980	0.31
0.048		1.400	0.76	0.005		1.500	0.25
0.025		1.050	0.55	0.001		1.120	0.11
0.018		0.905	0.47	0.000		0.940	0.03
0.012		0.760	0.38	0.000		0.705	0.03
0.000		0.110	0.03	0.000		0.105	0.03

Table A4: Pressure Drops and Calculated Air Infiltration for
Trials 11 to 14

PPENDIX 4

CMHEPTANCE APPLICATION

APPLICATION - BUILDING MATERIALS EVALUATION REPORT

IMPORTANT: Please read attachments 1 and 2 carefully before completing this application. Fill in the UNSHADED areas only, using BLOCK LETTERS or TYPEWRITER. CMHC reserves the right to edit this submission in accordance with its conventions for Materials Evaluation.

PROPOSANT CLASSIFICATION (CHECK (✓) ONE)		MASTERFORMAT REFERENCE							
☒ Prime Manufacturer	☐ Sole Canadian Distributor								
☐ Other (Please specify) _____		CONTROL CODE							

TRADE NAME(S) OF PRODUCT: New Phoenix Exterior Wall Opening Covers

1.0 PRODUCT

PROVIDE A SHORT TECHNICAL NARRATIVE CORRESPONDING TO THE DESCRIPTION IN THE APPLICABLE STANDARD OR THE NATIONAL BUILDING CODE OF CANADA

The product is a two component fitting that reduces or eliminates air, water, dirt and insect infiltration through the exterior sheathing of wood framed buildings as a result of penetration by electrical services. A secondary objective is to produce a more aesthetic appearance to such openings.

No applicable standards exist for this product to the best of the applicant's knowledge.

2.0 PROPONENT

ENTER THE FULL COMPANY NAME AND MAILING ADDRESS

New Phoenix Manufacturing inc.

8826 - 93 Avenue

Fort Saskatchewan, Alberta

Tel 149 (403) 992 1677

3.0 MANUFACTURED AT

ENTER THE FULL CIVIC ADDRESS OF THE MANUFACTURING FACILITY

4.0 DESCRIPTION

PROVIDE A DETAILED DESCRIPTION OF ALL THE PRODUCT'S COMPONENTS AND DESCRIBE THEIR PHYSICAL RELATIONSHIP TO EACH OTHER

The Exterior Wall Opening Cover consists of -

1. an injection molded base section (ABS plastic) and,
2. a vacuum formed PET (polyethylene terephthalate) trim piece.

The base section is attached to the sheathing with screws or nails. Caulking may be applied between the base section and sheathing. The base section forms a frame to finish siding against (wood, vinyl, aluminum or stucco). It also provides a smooth sealing surface for duplex electrical receptacle all-weather cover plates.

The trim piece fits into the base section to cover and finish the siding opening. The trim is held in place by the receptacle cover plate or by the electrical light fixture as the case may be.

5.0 USAGE AND LIMITATIONS

FULLY DESCRIBE THE USES FOR WHICH THE PRODUCT

DESIGNED

Currently 2 models exists.

1. electrical duplex receptacles
2. standard exterior lights using a saucer box.

Eventually models may be forthcoming to handle water bibs, dryer vent outlets and similar penetrations.

Its functions are two-fold, namely;

1. to reduce infiltration of air, water, dirt and insects to increase the structural longevity of frame construction.
2. to provide an aesthetic siding finish while reducing labour costs.

6.0 ASSESSMENT

6.1 COMPLIANCE TO BUILDING CODES AND STANDARDS

6.2 PERFORMANCE

6.3 LONGEVITY

PROVIDE SUMMARY OF WARRANTY DETAILS

The wall coverings are warranted for one year. The design is such that the exposed trim piece can be readily replaced in minutes by non-skilled labour.

7.0 INSTALLATION

SUMMARIZE ESSENTIAL INSTALLATION INSTRUCTIONS. ANY CONDITIONS OF USE IMPOSED BY THE PROPONENT SHOULD BE ENTERED HERE.

See attached sheet.

8.0 IDENTIFICATION

CONDITIONS

The proponent, upon affixing his signature to this application for a Building Materials Evaluation Report, agrees to:

- a) permit representatives of the CMHC Materials Evaluation Department or its authorized agents, without prior notice, to enter the premises specified on this application for the purpose of inspecting the manufacturing facilities and/or to designate samples for testing.
- b) obtain permission for representatives of the CMHC Materials Evaluation Department or its authorized agents to enter the premises of third parties to inspect examples of the product actually in use as part of a building.
- c) provide advance authorization to the testing laboratory, to forward one original copy of any report that may result from testing the product represented by this application, directly to the CMHC Materials Evaluation Department.
- d) indemnify the Corporation and each of its officers, servants, and agents for all loss, damage, damages, costs, expenses, claims, demands, actions, suits or other proceedings of every nature and kind arising from or in consequence of the issuance of this report or any use which is made thereof, whether such loss, damage, damages, costs, expenses, claims, demands, actions, suits or other proceedings are occasioned to be made or brought against the Corporation or its contractors, officers, servants or agents or the applicant, its officers, servants or agents or any other person or persons, corporation or corporations.
- e) make no use whatsoever, of the Corporation's name, logo or initials without the express written consent of the Corporation.

The proponent understands that, if during the course of an evaluation, it becomes apparent, in the opinion of CMHC that the product under evaluation may pose any danger to the health or safety of the user, CMHC will advise the proponent and any appropriate regulatory authorities of the potential danger.

NAME AND POSITION OF AUTHORIZED OFFICER: (Please Print)

DATE

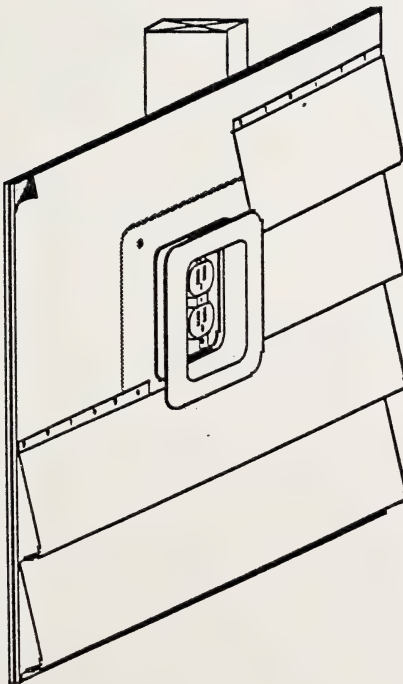
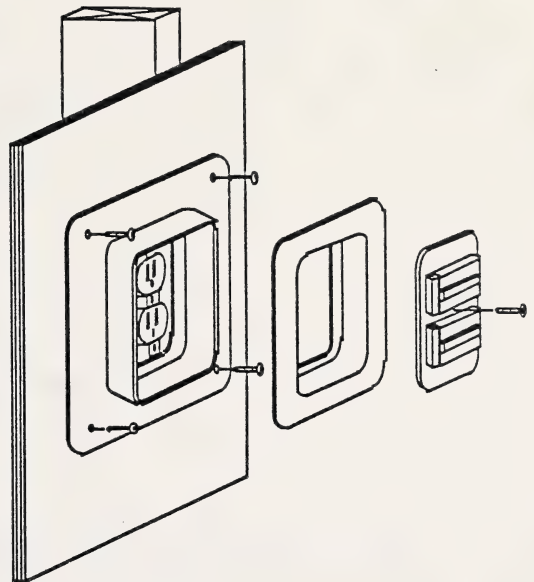
SIGNATURE

EXTERIOR WALL OPENING COVER

manufactured by

NEW PHOENIX
MANUFACTURING INC.

8826-93 Avenue
Fort Saskatchewan
Alberta
T8L 1A9
(403) 992-1677



INSTALLATION PROCEDURE

1. Mount the outlet box to the stud so that the box is flush with the sheathing surface.
2. Apply caulking to line on rear of base flange and attach to sheathing with screws or shingle nails, using the holes provided.
3. Apply building paper and exterior wall finish such as vinyl, wood or metal siding, stucco or brick veneer.
4. To complete the installation, install the top hat trim piece and weather proof outlet cover.

APPENDIX 5

ELECTRICAL PROTECTION BRANCH LETTER



File 6.5.1

LABOUR
General Safety Services Division
Electrical Protection Branch

Princeton Place, 10339 - 124 Street, Edmonton, Alberta, Canada T5N 3W1 403/427-6868

May 28, 1987

Enduro Siding Ltd.
8826 - 93 Avenue
Fort Saskatchewan, Alberta
TSL 1A9

Attention: Mr. Fred Arbter

RE: Exterior Wall Opening Cover

Further to our meeting of May 26, 1987 regarding the use of the above mentioned product around exterior weatherproof receptacles, lights, etc.; we would advise that as the proposed product is non-electrical, it does not require approval by this Branch.

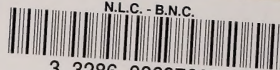
The installation of the "exterior wall opening cover" as indicated on your drawing #D2111 will be considered acceptable by this branch provided that no part of the "exterior wall opening cover" impedes the opening of the outlet boxes whatsoever. We agree however, that the installation of "exterior wall opening covers" would enhance the compatibility between the siding on a building and the exterior outlet boxes.

Per: _____
S. MISYK
Electrical Inspector

SM:jf

C.R. WHITE, SUPERVISOR OF ELECTRICAL INSPECTIONS
EDMONTON REGION PHONE NO. 427-6868

N.L.C. - B.N.C.



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